CLAIMS

1. An engineered structure comprising:

a first laminate comprising a plurality of constituent plant material layers, the plurality of constituent plant material layers comprising one or more first layers and one or more second layers, each plant material layer being adhered to an adjacent plant material layer via one or more respective glues,

wherein each first plant material layer is a densified plant material layer having a density greater than or equal to 1.15 g/cm^3 and a mechanical strength greater than or equal to a first value, and

each second plant material layer is a plant material layer having a density less than 1.15 g/cm^3 and a mechanical strength less than the first value.

2. The engineered structure of claim 1, wherein:

the densified plant material forming one, some, or all of the one or more first layers is a densified wood or densified bamboo; and/or

the plant material forming one, some, or all of the one or more second layers is a native wood or native bamboo.

3. The engineered structure of claim 1, wherein:

one, some, or all of the one or more second layers comprises one or more pieces of non-densified plant material that retains a native microstructure of cellulose-based lumina of the plant material; and/or

one, some, or all of the one or more first layers comprises one or more pieces of densified plant material, with cellulose-based lumina of a native microstructure of the plant material being substantially collapsed.

4. The engineered structure of claim 1, wherein:

one, some, or all of the one or more first layers comprises lignin-compromised plant material,

the lignin-compromised plant material comprises modified lignin therein, and

the modified lignin has shorter macromolecular chains than that of native lignin in the natural plant material.

5. The engineered structure of claim 4, wherein a content of the modified lignin in the one, some, or all of the one or more first layers is at least 90%, on a weight percentage basis, of a content of the native lignin in the natural plant material.

6. The engineered structure of claim 4, wherein the one, some, or all of the one or more first layers comprises a salt immobilized within a cellulose-based microstructure of the lignin-compromised plant material, and the salt is formed by reaction of an alkaline chemical with an acidic degradation product of native hemicellulose of the plant material.

7. The engineered structure of claim 1, wherein:

one, some, or all of the one or more first layers comprises lignin-compromised plant material, and

the lignin-compromised plant material comprises at least partially delignified wood.

8. The engineered structure of claim 7, wherein:

the plant material is a hardwood or bamboo, and a lignin content of the at least partially delignified plant material is between 0.9 wt% and 23.8 wt%, inclusive; or

the plant material is a softwood, and a lignin content of the at least partially delignified plant material is between 1.25 wt% and 33.25 wt%, inclusive.

9. The engineered structure of claim 1, wherein each first layer consists essentially of densified plant material.

10. The engineered structure of claim 1, wherein:

one, some, or all of the one or more first layers is disposed as a respective outermost layer of the first laminate; and/or

the one or more first layers encloses the one or more second layers in a cross-sectional view.

11. The engineered structure of claim 1, wherein the one or more first layers fully encloses the one or more second layers on all sides.

12. The engineered structure of claim 1, wherein:

the second layers comprise a stack of plant material boards arranged such that adjacent plant material boards have orthogonal orientations, and the stack of plant material boards is disposed between a pair of the first layers so as to form a reinforced cross-laminated timber (CLT) structure; or

the first laminate comprises a plurality of the second layers and a pair of first layers, each second layer comprising one or more plant material segments, the second layers being arranged in a stack such that adjacent second layers have parallel orientations, the stack being disposed between the pair of first layers so as to form a reinforced glued laminated (glulam) structure; or

the first laminate comprises a plurality of the second layers and a pair of first layers, each second layer comprising one or more plant material veneers, the second layers being arranged in a stack such that adjacent second layers have parallel orientations, the stack being disposed between the pair of first layers so as to form a reinforced laminated veneer lumber (LVL) structure.

13. The engineered structure of claim 1, further comprising:

a second laminate comprising a second plurality of constituent plant material layers, the second plurality of constituent plant material layers comprising one or more third layers and one or more fourth layers, each plant material layer being adhered to an adjacent plant material layer via one or more respective glues; and

a web extending between the first and second laminates,

wherein each third layer is a densified plant material layer having a density greater than or equal to 1.15 g/cm^3 and a mechanical strength greater than or equal to a second value,

each fourth layer is a plant material layer having a density less than 1.15 g/cm^3 and a mechanical strength less than the second value,

the web and the first and second laminates together form an I-joist, and

the first and second laminates form first and second flanges, respectively, of the I-joist.

14. The engineered structure of claim 13, wherein the first value, the second value, or both are 100 MPa.

15. The engineered structure of claim 1, wherein:

the first laminate has a first cross-sectional area, and the first laminate has a mechanical strength greater than a laminate structure having the first cross-sectional area and formed using only the one or more second layers with the one or more glues; or

the first laminate has a first cross-sectional area and a mechanical strength, and the first cross-sectional area is less than that of a laminate structure having the same mechanical strength and formed using only the one or more second layers with the one or more glues.

16. A method comprising:

providing one or more first layers, each first layer comprising a densified plant material having a density greater than or equal to 1.15 g/cm^3 and a mechanical strength greater than or equal to a first value;

providing one or more second layers, each second layer comprising a plant material having a density less than 1.15 g/cm^3 and a mechanical strength less than the first value; and

coupling the one or more first layers to the one or more second layers via one or more respective glues so as to form a laminate.

17. The method of claim 16, wherein:

(b3) the plant material of one, some, or all of the one or more first layers comprises densified wood or densified bamboo;

(b4) the plant material of one, some, or all of the one or more second layers comprises native wood or native bamboo; or

both (b3) and (b4).

18. The method of claim 16, wherein the providing the one or more first layers comprises:

subjecting one or more pieces of natural plant material having native lignin therein to a chemical treatment so as to compromise the native lignin, thereby forming one or more pieces of lignin-compromised plant material; and

compressing the one or more pieces of lignin-compromised plant material to form the densified plant material of the one or more first layers,

wherein the density of the densified plant material after the compressing is greater than a density of the natural plant material prior to the subjecting.

19. The method of claim 18, wherein the subjecting to the chemical treatment comprises:

infiltrating the one or more pieces of natural plant material with one or more chemical solutions; and

after the infiltrating, subjecting the one or more pieces of natural plant material with the one or more chemical solutions therein to a first temperature of at least 80 ºC for a first time, so as to form the one or more pieces of lignin-compromised plant material,

wherein after the subjecting, the one or more pieces of lignin-compromised plant material has modified lignin therein, and the modified lignin has shorter macromolecular chains than that of native lignin in the piece of natural plant material.

20. The method of claim 19, wherein, after the subjecting to the first temperature for the first time:

(b5) a content of modified lignin in the one or more pieces of lignin-compromised plant material is at least 90%, on a weight percentage basis, of a content of the native lignin in the one or more pieces of natural plant material;

(b6) a content of modified lignin in the one or more pieces of lignin-compromised plant material is at least 20 wt%; or

both (b5) and (b6).

21. The method of claim 19, wherein, after the subjecting to the first temperature for the first time, a salt of an alkaline chemical is immobilized within a cellulose-based microstructure of the one or more pieces of lignin-compromised plant material, and the salt is formed by reaction of the one or more chemical solutions with an acidic degradation product of native hemicellulose in the one or more pieces of natural plant material produced by the one or more chemical solutions.

22. The method of claim 18, wherein:

after the subjecting to a chemical treatment, the one or more pieces of lignin-compromised plant material is at least partially delignified, and

the subjecting to the chemical treatment comprises partial or full immersion of the one or more pieces of natural plant material in one or more chemical solutions at a second temperature

for a second time, so as to remove at least some lignin from the one or more pieces of natural plant material.

23. The method of claim 16, wherein each first layer consists essentially of densified plant material.

24. The method of claim 16, wherein the first and second layers are coupled in the form of a reinforced cross-laminated timber structure, a reinforced glued laminated structure, a reinforced laminated veneer structure, an oriented strand board structure, an I-joist structure, or a part of any of the foregoing.